EFFECT OF LIQUID PROPERTIES (WATER AND LIME JUICE) ON SPRAY CHARACTERISTICS OF DEFLECTED FLAT SPRAY NOZZLE (AL-75)

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ABSTRACT

Nowadays, the application of the nozzle has been widely used in the industry. The main factor that influences the spray is pressure of the liquid and air, type of nozzle, type of spray and the viscosity of the liquid. The problem in this research is to determine minimum liquid pressure used for atomization. This study is on characteristic with different ratio of liquid properties which can affect the spray behaviour for this spray such as spray angle, spray development and velocity. The objective for this research is to get the best atomizer within 1 bar to 3 bar liquid pressure for household piping. For this study, the pressure of liquid used was 1 bar, 2 bar and 3 bar, whereas the pressure of air used was 1 bar, 3 bar and 6 bar. Another objective is to identify characteristic study of spray angle, spray development and velocity of flat fan spray nozzle by using different liquid properties. 3 different fluids were tested with deflected flat spray nozzle (AL-75); 100% water, L10W90 (consist of 10% lime and 90% water) and L30W70 (consist of 30% lime and 70% water). Final objective is to validate result for spray angle and velocity between experiment and simulation using ANSYS CFX version 15.0. Based on the obtained results, the duration of fully development for deflected flat spray nozzle (AL-75) operated at the combination of 3 bar liquid pressure with 3 bar air pressure was 24ms, compared to spray nozzle operated at the combination of 1 bar liquid pressure with 1 bar air pressure with 32ms. This is because, an increase in pressure were decreases the duration for spray pattern to be fully developed. Velocity of 100% water was the highest compared to L10W90 and L30W70. This is due to the fact that as viscosity increased, the velocity of spray decreases. Spray angle result shows that water have wider angle compared to L10W90 and L30W70. As viscosity increased, the spray angles become narrow and simultaneously reduce the spray angle.

ABSTRAK

Pada masa kini, penggunaan muncung telah digunakan secara meluas dalam industri. Masalah kajian ini adalah untuk menentukan penggunaan tekanan rendah cecair untuk pengabusan. Kajian ini memberi tumpuan kepada ciri-ciri dengan nisbah cecair berbeza yang boleh mempengaruhi tingkah laku semburan seperti sudut semburan, perkembangan semburan dan halaju. Objektif kajian adalah mendapatkan pengabusan yang terbaik dalam tekanan 1 bar hingga 3 bar cecair untuk paip rumah. Untuk kajian ini, tekanan cecair yang digunakan adalah 1 bar, 2 bar dan 3 bar, manakala tekanan udara yang digunakan adalah 1 bar, 3 bar dan 6 bar. Objektif seterusnya adalah mengenal pasti ciri kajian sudut semburan, perkembangan semburan dan halaju muncung semburan rata dengan menggunakan cecair yang berbeza. 3 cecair yang berbeza telah diuji dengan muncung semburan kipas rata; 100% air, L10W90 (terdiri daripada 10% limau dan 90% air) dan L30W70 (terdiri daripada 30% limau dan 70% air). Objektif terakhir adalah untuk mengesahkan keputusan sudut semburan dan halaju daripada perbezaan eksperimen dan simulasi menggunakan ANSYS CFX versi 15.0. Berdasarkan keputusan, tempoh perkembangan sepenuhnya untuk muncung semburan rata (AL-75) pada kombinasi tekanan cecair 3 bar dengan tekanan udara 3 bar adalah 24ms, berbanding semburan muncung beroperasi pada gabungan 1 bar tekanan cecair dengan 1 bar tekanan udara 32ms. Ini kerana, peningkatan dalam tekanan mengurangkan tempoh untuk corak semburan. Halaju 100% air adalah yang tertinggi berbanding L10W90 dan L30W70. Ini disebabkan kelikatan meningkat, halaju semburan berkurangan. Sudut semburan menunjukkan bahawa air mempunyai sudut yang lebih luas berbanding L10W90 dan L30W70. Kelikatan meningkat, sudut semburan menjadi sempit dan pada masa yang sama mengurangkan sudut semburan.

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LIST OF SYMBOLS AND ABBREVIATIONS

CFD	-	Computational Flow Dynamics
3D	-	3 Dimensional
ρ	-	Density
D	-	Diameter
μ	-	Dynamic Viscosity
v	-	Velocity
VOC	-	Volatile Organic Compounds
KH2PO4	-	Monopotassium Phosphate
COD	-	Chemical Oxygen Demand
RO	-	Reverse Osmosis
La(NO3)3.6H2O	-	Lanthanum (II) Nitrate Hexahydrate
Mn (NO3)2.4H2O	-	Manganese (II) Nitrate Tetrahydrate
Co(NO3)2.6H2	-	Cobaltous Nitrate Hexahydrate
LaMnO3	-	Lanthanum Manganate
LaCoO3	-	Lanthanum Silicate Oxypatite
H	-	Hydrogen
O	-	Oxygen

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1. Analysis mist spray development with Al-75 nozzle by using high speed camera. AIP Conference Proceedings 1831, 020023 (2017); doi: http://dx.doi.org/10.1063/1.4981164

CHAPTER 1

INTRODUCTION

1.1 Background study

In the 20th century, the demand of mist spray nozzle is very high in various companies especially which involve with cleaning process. Multiphase flow is described as any fluid consisting of more than one phase or component. There are two types of nozzle that had been widely used in the industry, namely deflected flat spray nozzle and jet nozzle. The jet nozzle performs quite well compared to flat spray nozzle. However, it uses more water. Most industry wanted to reduce the usage of water to cut the cost incurred during production. As for deflected flat spray nozzle, only a small amount of water mixed with lime was used. The main objective of using the deflected flat spray nozzle in kitchen hood is to clean the grease and at the same time act as surface cooler.

In spraying system, nozzles break the liquid into the droplets. Droplet size refers to the size of the individual drops that comprise a nozzle spray pattern. There are many factors that affecting the fluid properties of the spray such as surface tension, viscosity and density (Graco, 1995). For the surface tension, it is important to stabilize a fluid and the higher the surface tension can produce the larger average droplet size upon the atomization. The viscosity can cause the fluid to resist agitation and tending to prevent its breakup. The increase viscosity produces the slower velocity for the spray nozzle and the larger droplets were produce. For the spray angle, the higher the viscosity, the narrow the spray angle was produced. The density can cause the fluid to resist acceleration. Higher density tends to result in a larger average droplet size (Nuyttensa et al., 2007)

The nozzle used for this study is deflected flat spray nozzle (AL-75). This nozzle was used because the lower pressure for air and water can be applied into it. These nozzles are used to clean up the filter by using water; however, the cleanliness quality of the filter is not satisfactory because water is not good cleaning agent to clean the oil and grease in the filter. Therefore, the organic citric acid mix with water was suggested for another alternative as a cleaning agent. Organic citric acid is good agents to kill bacteria, mold and mildew for great general disinfecting and safety cleaning agent. The operation pressure used for this experiment is 1 bar, 2 bar and 3 bar for liquid pressure and 1 bar, 3 bar and 6 bar for air pressure.

The software that was used in this research was ANSYS software. ANSYS software is widely used in variety of industry involving engineering projects because it can design the process. For this research, the ANSYS software can predict the simulation in the nozzle. The simulations using ANSYS software provide prediction on flow behaviour of the nozzle.

1.2 Problem statement

Nowadays the spray nozzle is often used for industry such as spraying in painting, filtering and cleaning. Most of pressure use to atomize the liquid are above 6 bar for example jet nozzle atomized above 150 bar (Tamaki & Shimizu, 2002) while macro spray nozzle and single point nozzle atomized at 34 bar (Hannifin, 2013) and pressure swirl nozzle atomized at 6 bar liquid pressure (Schuchmann & Gaukel, 2015). The problem in this research is to determine minimum liquid pressure used for best atomization in household piping system. According to this research also focus on characteristic study with different ratio of liquid properties which can affect the spray behaviour such as spray angle, spray development and velocity.

1.3 Objectives

The objectives of this study are:

i. To obtain the best atomizer configuration within 1 bar to 3 bar liquid pressure for household piping and 1 bar, 3 bar and 6 bar for air pressure.
ii. To identify characteristic study by using different liquid properties.
iii. To validate the Computational Fluid Dynamic (CFD) result using ANSYS CFX with experimental for spray angle and velocity.

1.4 Scope of study

The scope of study is limited to:

i. Liquid pressure used in experiment are 1 bar, 2 bar and 3 bar, and air pressure from 1 bar, 3 bar and 6 bar.
ii. Percentage ratio of water and limes as liquids
   a) 10% lime juice and 90% water (L10W90)
   b) 30% lime juice and 70% water (L30W70)
   c) 100% of water (L0W100)
iii. Deflected flat spray nozzle (AL-75) was used in the experiment.
iv. High speed camera (Phantom V710) used for detected spray development with the following specifications; maximum resolution of 1280x800 at 7500 fps, minimum resolution of 128x8 at 1400000 fps (optional) and 685800 fps (standard). Image sensor of MOS sensor having 20 μm pixel size. Phantom Camera Control (PCC) with speed of 7.5 Gpx/Sec and recording time of 2.97s at maximum frame rate.
v. Nikon D7000 Camera used to capture the spray angle with 16.9 million effective pixels and the speed of 1/8000. The flash sync or frame rate of this camera is 1/250 per seconds. CMOS Image sensor of 23.6x15.6 mm.

vi. Software used in experiment:

a) ImageJ

b) Tracker

c) Phantom Camera Control

d) Adobe Photoshop CS5 Extended

vii. Software used in simulation:

a) Computational Fluid Dynamics (CFD) ANSYS CFX version 15.0 for simulation

b) Turbulence model used for simulation is K-epsilon

1.5 Outline of the thesis

This outline provides a summary of the contents of each chapter in this research and it is given as below:

CHAPTER 1 has introduced the alternative used for the spray nozzle, the pressure and liquid properties were used for this study.

CHAPTER 2 explains the necessary background for the deflected flat spray nozzle, the theory for spray nozzle and tools that were used for this experiment and simulation that are involved in this thesis.

CHAPTER 3 discussed the procedures for the experimental and simulation set up as well, including experimental tools and parameter setup for ANSYS software.

CHAPTER 4 present all the experiment result and the validation simulation result by ANSYS software. Discussed the result get from the experiment and simulation.

CHAPTER 5 conclude the result from entire thesis and suggest the recommendation for the future studies.

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